Comments on Lithic Technology & Experimental Archaeology

Since the excavations by Dr. L.S.B. Leakey at Olduvai, we now have evidence of man using stone tools for approximately two million years. This gives one pause when we realize that the Stone Age accounts for at least 99.5 percent of human history. Since artifacts of wood, bone and other perishable materials had little chance of surviving the ravages of the elements and time, we must rely primarily on stone tools to attempt an interpretation of the behavior of prehistoric man during the Stone Age. In brief - 99.5 percent of the history of mankind is represented by the Stone Age and if we correctly approach an analysis of both his stone tools and the manufacturing debitage we can attempt an interpretation of his behavior paterns and attempts at survival. I think Dr. Leakey summed it up very well when he said "For the students of lithic technology, the stone tools of man represent fossilized human behavior patterns.

Today, stone tools are still used in only a few remote places in the world and these societies, too, will probably soon substitute the more versitile metal implements for their stone tools. For this reason, it is imperative that any information regarding the manufacture and use of stone implements - whether past or present - be recorded. It is unfortunate that existing stone age societies generally lack the sophisticated skill of workmanship of some of the prehistoric lithic industry workers. But we seem to note a degeneration of this skill even at the end of the stone age. For this reason, experimental archaeology - and in this case I mean the replication of prehistoric stone implements - can provide information about the manufacturing methods, techniques and maybe even the uses of tools of the stone age. Certainly, experimental replication will help the typeologists and functional experiments can give clues to how and why the tools were used. By experiment, we will not only be more capable of defining techniques but will also be able to evaluate the many stages necessary to finish the product and consider the requisite import of appraising broken, malformed and reworked tools. For those who are doing computer analysis this is most important for we should allow for inferior workmanship, miscalculation, intentional and unintentional fracture, deficient material, interruption of the worker, the learner, etc. But experimental archaeology must be related and compared to definite aboriginal concepts of a particular technology or clusters of techniques and then used to replicate the stages of manufacture from the raw material to completion.

Throughout the stone age, man made his stone artifacts by applying force to various lithic materials to detach flakes from the mass and ultimately shape and form a functional tool. He used various types of force and diverse fabricators. The flake or blade (specialized flake) bears the positive features while the flake scar on the core retains negative features. Both the flake and the core may be formed into more complex tools by the removal of additional flakes and when complete these are flake and core tools.

To the casual observer, flakes and their counterparts may look much the same other than the obvious observation of their varying dimensions. But, in reality, flakes and their scars are very distinctive and can give clues to the manufacturing technique, direction of force, type of applied force, platform preparation, curvature of the flake, flake termination, stages of manufacture, type of tool used to induce fracture and the type of artifact being made. An analogy might be the comparison of fingers by their shape and tips rather than using the sophisticated science of fingerprinting. However, flakes detached by the same technique may have minor differences but each will only make perfect contact with its original flake scar. But a drastic change of technique will usually show major differences in characteristics of the flake and scar. Unfortunately, there is little recovery of pressure flakes other than pressure blades. Most pressure flakes are small and have a tendency to crush during detachment and consequently are lost at the workshop area. Therefore, we are generally forced to make our analysis of pressure techniques from the scars retained on the artifact.

Rather than burden the flake analyst with lengthy cumbersome lists of attributes, I would like to call attention to some of the problems of flake analysis and interpretation based on the manufacture of stone implements. The flake or blade character is influenced by many factors. To name a few - the material, the implements used to apply the force, the applied techniques, the thermal alteration of the lithic material or the lack of alteration, and the degree of skill of the artisan.

Force is applied to the stone to induce fracture to detach the flake and leave its corresponding scar on the mass. Both flakes and flake scars retain features which give clues to interpret the aboriginal manufacturing processes. The flake retains more diagnostic features than the flake scar because the platform usually adhers to the flake and it bears other characteristics and traits which can indicate the mode of detachment and stage of manufacture. It permits the analyst to consider the platform character of the proximal end and evaluate the termination of the distal end. It retains the positive character of the bulb of force; designates the area contacted by the fabricator; sometimes has lips and overhangs, curvature, undulations; allows inspection of both the dorsal and ventral surface; denotes form and dimensions and we can often differentiate between the worker's intent and the error. But the flake scar is not without diagnostic features. It can indicate the direction of applied force, depth of the negative bulbar scars, flaking rhythm, manner of holding, spacing, use of ridges to guide direction of flake removal, manner of termination, thinning, notching, serrating, etc. For this reason, experimental replication of prehistoric stone artifacts has been useful to replicate, interpret and record the subtle variations of flakes and scars resulting from different techniques. Certainly, experimental archaeology helps typeology. For example, some artifacts may look morphologically the same but be made by entirely different techniques. So if we have some knowledge of stoneworking we can more readily define these differences.

Because stone tools have an almost universal distribution covering a vast time span and represent independent developments of multitudes of techniques, it is doubtful if all of these techniques will ever be fully understood or defined. However, as the science of lithic technology progresses, experimental archaeology will make possible the associations of the same or parallel techniques which have features and characteristics in common. Duplicate or parallel techniques will not indicate or prove a direct connection between extinct societies for, no doubt, innumerable independent techniques were developed and some can be outright inventions which have no parallel. Specific flake styles are possible by using diverse approaches to obtain finished products which are similar but not identical.

Many factors must be considered in determining the technique. We must first evaluate the vast differences in lithic materials. I can not stress this too much and have yet to visit a quarry without evidence of previous aboriginal use and giving mute testimony to the workers' discriminating choice of superior materials. Examples of tested and discarded materials are abundant in quarry sites. And I generally concur with their discard reasoning e.g. imperfections in the material, containing cleavage planes, lack of elasticity, wrong size, poor texture, non-homogeneous, etc. Regarding material, let's discuss obsidian. Obsidian is described geologically as a volcanic glass which is vitreous, isotropic, black in color and having the ability to fracture chonchoidally. It was universally preferred by toolmakers for certain tools because under controlled conditions it responded to the workers intent and gave flakes, blades and tools with a keen edge. For agriculture and chopping tools he generally preferred a more resistant material such as basalt, flint, chert, etc. Yet obsidian varies in workability. These variabilities are: its elastic qualities, keenness of edge, mineral constituents, differences in geological age and formation, and all of these qualities can and do influence the workability of the material. Obsidian also comes in a variety of colors and sheens. The worker must also appraise obsidian containing impurities, inherent stresses and strains, temperatures of solidification, flow structures, gas bubbles and size. All of these good or bad qualities can and do influence control or restrict the outcome of the end product whether the desired implement be a flake, blade or a multiple flaked implement. Predominantly siliceous rocks like quartzites, flint, chert and endless varieties of chalcedonies are even more variable. The worker must either modify or develop techniques which conform and respond to the material being worked. For example - a whole different cluster of methods and forces would have to be applied to quartzites and basalts when the worker is accustomed to working with more vitreous rock such as opal, obsidian or heated siliceous material.

Often lithic material was available in limited quantity, quality, size and variety which had a direct bearing on the endeavors of the stoneworker. Over large geographical areas, ideal lithic material was scarce and often it was obtained from considerable distance. Discriminating stone workers who had access to a varity of materials selected their stone according to the intended design and functional purpose. When they intended their tools to be subjected to repeated impact and hard rigorous treatment they selected material resistant to shock to insure a longer lifespan for the implement. When they wanted tools with a keen cutting edge, they selected highly vitreous material. For example: certain obsidians with superior elastic qualities were selected for manufacturing pressure blades and other obsidians not as elastic were more desirable for artifacts which required multiple flaking. Silica is compounded and blended by nature with other elements giving varieties with diverse qualities - some desirable and some undesirable.

The toolmaker was a good geologist and knew how to choose superior material for specific needs.

Since we are discussing materials, let's consider those who had access to only inferior material and yet made adequate tools. When you are analyzing such tools don't indiscriminately write off tools having random flaked tools with step or hinge fractures as being the result of inferior workmanship. But rather consider the material and you may discover that you have a superior workman who was forced to use inferior material. Don't put these tools aside and label them as "crude" but do combine your evaluation of the material and workmanship and this may change your opinion of the group of people forced to survive under these conditions.

As some metals are annealed and tempered, so also may siliceous rocks be altered by controlled application of heat. At some early period of time, man found that internal stresses and strains inherent in the rock could be relieved by subjecting the stone to controlled heat. This made the material more homogeneous, ~~thereby~~ changing its texture from coarse to vitreous and thus improved the flaking quality and enabled the worker to control flake detachment and produce a tool with a sharper edge. Often lithic material containing impurities will undergo a color change during alteration. When this happens, the color change will be more pronounced near the exterior of the altered material. But controlled heating does not change the texture of the exterior or exposed surface. Only when a flake has been removed to expose the interior surface can the texture change be noted. We do not, as yet, know when prhistoric man discovered this annealing process, but Dr. Francois Bordes has noted the alteration as far back as Solutrean.

Often in a collection or at an excavation we will find an aboriginal flake, blade, core or artifact which will retain a portion of the natural surface of the stone, ~~on the dorsal side~~. This will help in determining alteration of the material for the exposed surface does not respond to heat treatment. But if the ventral side of the flake or blade is lustrous in contract to the dorsal side, then we can safely assume that the material was subjected to thermal alteration. When we do not have the debris and must rely on only the flaked surface of artifacts such as projectile points, cores, etc., we can look for a facet of the natural material which might be still adhering to the face of the artifact. Then we can compare this facet with the flaked surface to determine if the material was altered. If the facet is dull and the flaked surface is lustrous and of a different texture than the the natural facet then we can be pretty sure the material was altered. With cores, we can detach a flake to note any difference on the ventral side. If such evidence is not obvious then we must resort to an experimental approach and conduct a controlled heating process on the same material to ascertain if the stone has been altered by heating.

Thermal alteration of lithic materials is a sophisticated process involving critical temperatures, correct duration of gradually raised and maintained heat exposure, controlled cooling process, and calculation of time and temperature according to the size, type and quality of the material being altered. Until one is familiar with the stone, each material must be tested individually. When the correct formula has been determined for a given material then any deviation in control of raising and lowering of temperatures will result in the material being unchanged or worthless. The temperature range for altering siliceous minerals will vary from 450°F to 1000°F. and only the trial and error method will determine the ideal temperature index. Basalts and obsidians respond to a much higher temperature without danger of crazing and they will withstand more rapid temperature changes than siliceous rocks. One archaeological example of the use of heat treatment are the Hopewell cores and blades from Flintridge, Ohio material. Analysis reveals that most of these were of treated flint.

The percussors and compressors used to form the stone tool definitely influence the character of the detached flakes and scars and the toolmaker selects his fabricator to conform to the size and type of material, the desired fracture dimension and one which will perform a specific technique or a group of related techniques. Hammerstones, billets, punches, compressors and all fabricating tools should be recovered from sites and their wear patterns studied to help determine the technique and type of applied force. For example: the edge ground cobble technique leaves a consistent wear pattern on the side of the hammerstone rather than on the end and these can often be mistaken for a rubbing stone. But when the wear patterns on these cobbles are properly interpreted they can indicate a distinctive type of blade and flake detachment.

There are three major and very general classes of flake detachment: Direct percussion, indirect percussion and pressure. A minor technique is the combined use of pressure and percussion. Flake detachment techniques involve a knowledge of elastic limits of the materials, Newton's law of motion, force, gravity, weight, mass, density, friction, levers, moment of force, center of gravity, stability of bodies, projectile motion and kinetic energy. This is, indeed, a comprehensive list of factors which must be mentally evaluated and rationed to accomplish the controlled fracture of lithic materials. It is highly unlikely that prehistoric man was aware of these scientific laws but as his techniques became more sophisticated he did take advantage of these principles.

The earliest stone tools were probably natural erosional products selected by man for their sharp cutting edges and he probably used spheroids as hammers or missiles. Direct percussion was probably mans' first approach to intentional fracture to form tools and expose useful cutting edges. This early technique was used to form a wide variety of percussion tools and involved many and varied percussion techniques. One of the simplest is described by Richard Gould (personal communication) when he observed the Australian aborigines in the process of toolmaking. They threw the lithic material against boulders and then selected flakes with sharp cutting edges to be used "as is" and others were selected to be modified into functional implements. This technique of using a fixed anvil stone is often called "block on block". When further refined, it will lead to other related techniques. But considerable more fracture control is possible when the material is not thrown against the anvil but, rather, is held in the hand and then struck on the anvil stone. This allows the worker to predetermine the point of contact and accurately detach his flake and expose an edge. It affords the worker more accuracy and the degree of velocity can be adjusted and proportioned according to the weight of the material being flaked and the desired dimension of the intended fracture. But even better control of the flake or blade detachment may be gained by the worker specially designing the part of the material to be contacted by the fixed percussor. This point of contact is known as the platform. There are many methods of platform preparation which have diagnostic value and influence the character of the flake or blade. A few examples of platform preparations are: Making the proper angle on a plane surface, isolating the platform area surface, removing the overhang from previous flake scars, grinding the surface, polishing the margin, faceting by the removal of one or more flakes, beveling, and the orientation of the platform with guiding ridge or ridges. As prehistoric man improved his stone toolmaking, he progressed from simply exposing an edge to flaking more of the surface. This evolution progressed from the first embryonic attempt to flaking handaxes with a natural surface butt then to entirely flaked handaxes and on to cores, blades, burins, projectiles,etc. During this time he also substituted antler, bone and hard woods for his stone hammer to flake his implements which enabled him to better control his flake detachment and make thinner tools. Progression continued to the Solutrean where we first note the use of pressure flaking. And so on to the New World where we find sophisticated techniques and combinations of techniques, fluting and a predominance of pressure work.

Time does not permit discussing the various types of percussion and pressure techniques but all involve proper preparation of the striking or pressing area, correct angle of applied force, control of applied forces, predetermined flake termination and other factors too numerous to mention. It is enough to say that both the flakes and their scars must be studied very carefully to arrive at any decision pertaining to the technique. Some of the problems which can often be answered by an evaluation of the lithic debric, broken and malformed artifacts are:

1. How was an artifact made and what tools were used to form it.
2. Why was the implement made in this particular form.
3. Why were certain lithic materials selected for specific artifacts.
4. How was the tool intended to be used.
5. What task was it to perform.
6. Was the tool a multi-purpose tool.
7. How was the tool held in order to perform a specific function.
8. Was the tool hafted.
9. How was the tool hafted.
10. What was the action of the tool on the objective material.
11. Was the tool pulled or pushed.
12. Does the tool strike or press the objective material.
13. Was the tool used for scraping or cutting.
14. How can the angle of the tool edge be compared to the resistance of the material being formed.
15. What is the difference between attrition and corn polish.
16. What causes the striations on the working edge of the tool.
17. What are the directions of the striations on the working edge of the tool.
18. Was the tool used as a burnisher.

19. Do some softer materials being formed have an abrasive action on the tool.

20. How can use flakes be identified as opposed to intentional retouch.

21. What are the characteristics of use flakes.

22. What is indicated by a series of use flakes of certain character, termination, change of angle, increased resistance, improper use, beginners or apprentices, mishandling.

23. Was the tool abandoned upon completion of the task.

24. Was the tool broken from accident, manufacture, due to imperfections in the material or during the functional performance.

25. Was the tool exhausted from resharpening.

These are only a few of the problems encountered when evaluating lithic material. Each flake or artifact must be consider independently. Then clusters of like attributes will have diagnostic significance.

Well, you say, this is all well and good but I am not a flintknapper and have no one to teach me and no access to debris for analysis. It is certainly not my intention to make a flintknapper out of every student, but even an attempt will give you a "feel" for controlling fracture and will help clarify the mechanical problems involved in making stone tools. So for those who are seriously interested in lithic technology I recommend at least a try in stone fracture. You need not become proficient at the art, but at least try it. If you don't have stone available for experiment then use building glass, old T.V. tubes, the bottoms of bottles, old procelain toilet bowls or anything that will respond like lithic material. Also, you are fortunate to be studying during a period when information on this art is readily available. Idaho State University has films for rent or sale showing the various types of pressure and percussion work and also has many publications on replication. Tom Hester has published a fine bibliography containing almost everything written on lithic technology. And we now have lithic technology courses available in several universities with many students teaching actual flintknapping. Many students have attended our summer field school in knapping and have become quite proficient at tool-making. Most of these graduates are available to give demonstrations and show actual manufacture and explain the implications of debitage. Also, in our major universities and museum there are large collections of extinct stone tools which we can use as models for replication and analysis. These collections often present a challenge to our ingenuity, inventiveness and personal resources to resolve techniques.

Barring these approaches you can practice experimental replication on your own as prehistoric man did. Francois Bordes and I indipendently learned this way and it was only by trial and error that we eventually achieved replication of many techniques. But this is slow and laborious and involves a lot of blood, sweat and tears so I would recommend the beforementioned methods. And let's not forget Halvor Skavlem, Anders Kragh, Gene Titmus and others who spent many years developing their own approach to replication. Another fine example is Jacques Tixier of the Museum of Natural History in Paris, France. He learned percussion from Francois Bordes and later, when he attended the lithic technology conference in LesEyzies, he learned the rudiments of pressure flaking from observing demonstrations by me and Francois Bordes. For years he practiced pressure work on his own and would send examples of his work to me with questions about removing overhang, obtaining a keen edge, platform preparation, angle of holding tool on the platform, angle of applied pressure etc. As a result, he became a first-rate flintknapper by experiment and correspondence. Having learned the value of debitage, he was then able to define the Capsian core technique. When he found cores and debitage at an excavation which contained the platform part, he was able to define the capsian cores and blades as a pressure technique. Since then he has become one of our most outstanding and reliable typeologists and has defined other techniques including replication of an ancient Etheopian blade technique.

It is certainly not my intent to infer that only toolmakers are qualified to interpret techniques and types. A case in point is Ruthann Knudson. She was intensely interested in Paleo-man's tools and intended to write her thesis on this subject. She was fortunate enough to have the benefit of Marie Wormington's vast knowledge of typeology and to work with her at her excavation in Kersey, Colorado. She was also present on several occasions when I visited at Kersey and gave demonstrations in toolmaking. Being a keen observer, she noted each step of manufacture and later studied the debitage. Then after examining paleo-man collections throughout the country she applied what she had observed and came up with an accurate technological description of many tools. When she attended our field school she brough her index card analysis of these tools along and in every instance her analysis was correct. In her case the school gave her a chance to actually try flintknapping and to verify her conclusions. So experimental archaeology has many approaches and I recommend them all or a combination of several to all students concentrating on lithic technology and typeology.

In conclusion, we all owe a vote of thanks to Dr. Earl Swanson and Dr. Marie Wormington for having the wisdom to stress the significance of this experimental approach for a better understanding of the behavior of Stone Age man.